

REMARKS

I. Claim Status

Claims 17-29, 32-44, and 60, which were examined in the parent application, have been canceled.

Claims 61-91 are now pending. Claims 61-84 were presented in this application of which claims 60 and 80-83 were independent.

Claims 61, 65 and 80-83 are amended. Claims 85-91 are added as new claims. Claims 61, 80, 81, 82, 83 and 85 are independent. No new matter has been added.

II. 35 USC 112, second paragraph

The office action rejects claims 61-67 and 69-89 under 35 USC 112, second paragraph, as indefinite. In support of the rejections, the examiner states that "Claims 61-89 are incomplete, because no step of surgery is recited."

In response, each independent claim is amended to recite ", thereby removing said tissue." Removing tissue is a form of surgery.

In support of the rejections, the examiner also states that "In claim 65 the term 'said generating said pump beam pulse as a multi mode beam ... said beam' lacks antecedent basis."

In response, claim 65 is amended to recite "said multi mode beam" instead of "said beam."

In support of the rejections, the examiner also states that, "Also, in claim 65 exactly what is intended to be encompassed by the term "a divergence greater than eight times the diffraction limit of said beam" is unclear because divergence as used in referring to beams of radiant energy is a quantity expressed in units of length (e.g., nm)"

In response, the applicant respectfully disagrees with the examiner's assertion that "divergence as used in referring to beams of radiant energy is a quantity expressed in units of length (e.g., nm)." In fact, divergence defines an angular limitation, and divergence is conventionally defined in angular unites, such as radians.¹ Accordingly, applicants traverse this grounds for rejection.

¹ A copy of the definition of "radian" from the Second Edition of "The Dictionary of Scientific and Technical Terms" is attached to this response as attachment 1.

In support of the rejections, the examiner also states that "further [sic] since the beam is multimode, exactly what the diffraction limit of such a beam is [sic] unclear, since for sufficiently large number of modes, the diffraction limit could theoretically be millimeters."

In reply, the applicants respectfully disagree since the examiner's conclusions are based upon the predicate that divergence is a measure of length, not angle, and that conclusion is incorrect.

In support of the rejections, the examiner also states that "For the purposes of examination, the term 'divergence' will be read as 'dimension' and the 'diffraction limit' will [sic] considered to be that of a single mode TEM00 beam."

In reply, the applicants point out that interpreting "divergence" to mean "dimension" is improper for the foregoing reasons. Moreover, claim 65, which is the claim to which the examiner's assertions regarding "diffraction limit" apply, expressly recites a "diffraction limit of said multi mode beam" and therefore the examiner's considering the recitation "diffraction limit of said multi mode beam" to mean the diffraction limit of a single mode beam, such as a TEM00 beam, reads out of the claim express limitation of a "multi mode beam" and is therefore improper.

III. 35 USC 103

A. Lin and Tan et al. - claims 61-63, 65-80 and 85-89

The office action rejects claims 61-63, 65-80, and 85-89 under 35 USC 103(a) as obvious in view of the combined teachings of Lin (US Patent) and Tan et al. () In support of the rejections, the examiner states that:

Claims 61-63, 65-80, and 85-89 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lin in view of Tang et al. Lin teaches performing corneal sculpting with radiation in the 2.5-3.2 micron range generated by an OPO with pulse width in the 1-40 nsec range. Tang et al[,] teach producing radiation in the range of Lin using a CPM KTP OPO pumped at about 1 micron, the pump thresholds are discussed as 0.5 mj corresponding to 30 kw peak power and 17 MW/cm². To produce 0.5 mj with a 30 kw pulse requires a pulse width of 17 nanoseconds to [sic; . To] produce a power density of 17 MW/cm² with 30 Kw pulse yields (assuming a circular beam cross section) a beam radius of 563 microns which is well in excess of eight times the diffraction limit of the single mode beam. It would have been obvious to the artisan of ordinary skill to employ the OPO of Tang et al[,] in the method of Lin, since the enables effective tuning in the desired range as taught by Tang et al; to employ a mirror that transmits the pump pulse at a forty five degree

angle thereto since the [sic; that] does not manipulatively affect the method and is notorious in the art; to tune the output to be in the 2.75-3.0 micron, since Lin gives no indication that this portion of Lin's range should be avoided, the claimed range is not critical; and wavelengths near 3 microns are notoriously useful for surgery, official notice of which is hereby taken; to increase the power of the pump beam by increasing the energy of the pump, since this would reduce the thermal damage to the non-linear material compared to increasing the pulse width official notice of which is hereby taken [sic ;] and to transmit pump radiation exiting the crystal to a second KTP crystal and interlace the resulting idlers, since these are equivalents [sic; and] provide no unexpected result and are known configurations in the art, official notice of which is hereby taken thus producing a method such as claimed. [Office action page 2 line 22 to page 3 last line; interpolation supplied.]

In response, the applicant respectfully traverses the rejections because they do not suggest the claimed inventions. The relevant teachings of the two references are discussed below followed by an explanation why they do not suggest the claimed inventions.

Column 9 lines 31-42 in Lin states that:

The basic laser also includes a mid-IR (2.5-3.2 microns) laser generated from optical parametric oscillation (OPO) using a near-IR laser (such as Nd:YAG or Nd:YLF, flash-lamp or diode-pumped) as the pumping sources and KTP or BBO as the frequency conversion crystals. The OPO laser has advantages over the Q-switched Er:YAG laser, including higher repetition rate (10-5,000 Hz) and shorter pulse width (1-40 n.s.). These advantages provide faster surgical procedure and reduced thermal damage on the ablated corneal tissue. Typical energy per pulse of the OPO laser is (0.1-10) mj. Greater detail on OPO was published by the inventor in Optical Communications, vol. 75, p. 315 (1990).

Claim 18 in Lin states that:

18. A method of performing corneal refractive surgery by reshaping a portion of the corneal surface in accordance with claim 1 in which the step of controlling said scanning mechanism includes controlling said scanning to scan a pattern of radial aligned slits of fixed area using a laser beam capable of photoablating corneal tissue for laser radial keratectomy.

Lin is silent regarding phase matching.

Moreover, Lin does not enable an OPO laser system for wavelengths in the 2.75 to 3.0 μm range. Lin cites at column 9 lines 41-42 to "Optical Communications", vol. 75, p. 315 (1990)² for details on OPO. However, that paper "report[s] the first demonstration of a

² A copy of "Optical Communications", vol. 75, p. 315 (1990) is attached to this response as attachment 2.

tunable mid-IR (1.8 - 2.4 μm) coherent source." See the abstract. The reported 1.8 - 2.4 μm wavelengths are outside of the wavelength ranges claimed herein. Lin contains no disclosure enabling OPO in the 2.75 - 3.0 μm wavelength range.

Tang et al. does not provide motivation to use an idler beam having a wavelength which is "between about 2.75 and about 3.0 microns" (amended claim 61) or is "about 2.75 and about 3.0 microns" (amended claim 80) in a procedure to remove tissue. Tang et al. does not enable an OPO laser system having an idler wavelength above about 2.80 μm . Tang et al. does not enable an OPO laser system having a wavelength of 2.75 to 3.0 μm that would be useful for surgery.

Tang et al. is a one page paper.³ Tang et al. discloses theoretical calculations (solid lines in figures 1a, 1b, and 2 and some experimental data (series of data points in figure 1a and two points in figure 2). Specifically, Tang et al.'s left hand column, second paragraph, starting "An initial theoretical comparison....") indicates that solid lines are theoretical predictions, not data. Moreover, Tang et al. is caption for figure 2 indicates that symbols of a circle, a diamond, a plus sign, and a capital X represent data thereby implying that the solid lines represent the theoretical calculations.

Furthermore, the caption for figure 1 states "Experimental data is also shown" implying that the solid lines are theoretical predictions and the set of square and triangular symbols in figure 1a represent data. In addition, Tang et al.'s right hand column lines 14-15 states that "Measured signal/idler wave tuning is shown also in Fig. 1" apparently referring to the square and triangular symbols shown in figure 1a.

Tang et al. center column last full paragraph lines 1-10 states that:

To compare and contrast the CPM device with the NCPM geometry, two 25-mm-long KTP crystals cut at ... , cut at $\theta = 90^\circ$, $\phi = 0^\circ$ and $\theta = 63.4^\circ$, $\phi = 0^\circ$ have been employed in our experiments. In the latter case, the calculated signal and idler wavelength pair at normal incidence are 1.714 μm and 2.69 μm respectively. The corresponding tuning rate about this point for the signal wave is 17.1 nm.deg⁻¹.

The caption for figure 1 states that the pump wavelength was 1.047 μm .

³The copy of Tang et al. provided with the office action upper left hand corner recites "266/CLEO'96/WEDNESDAY AFTERNOON". Presumably "266" is the page number, which is different from the page number identified in the Tang et al. citation in the PTO-892 accompanying the office action.

Figure 2 shows that the experimental data points are for data obtained near the intersection of the theoretical predictions for the threshold pump power and threshold intensity. This point defines a relative minima of the product of the threshold pump power and threshold intensity, indicating to one of ordinary skill in the art criticality to that value. Figure 1a shows data only for a two or three degree range of θ about 63.4 degrees, implying to one of ordinary skill in the art that no OPO lasing occurred outside of that range. That conclusion is consistent with the well known in the art fact that non critical phase matching is very sensitive to the value of the angle θ .

Tang et al. does not state the experimental value of the conversion efficiency to the idler beam. Tang et al. discloses (right hand column lines 10-14) a thirty percent conversion efficiency to the signal beam. Presumably, the conversion efficiency to the idler beam was lower than the conversion efficiency to the signal beam since Tang et al. cites signal beam conversion efficiency, not idler beam conversion efficiency.

The examiner asserts that "to increase the power of the pump beam by increasing the energy of the pump, since this would reduce the thermal damage to the non-linear material compared to increasing the pulse width official notice of which is hereby taken," thereby admitting that "power of the pump beam", "energy of the pump," and "the pulse width" were known factors and limitations relating to "thermal damage to the non-linear material." This application also discloses the criticality of limiting the pump power in order to avoid destroying the optics. See page 3 line 18 to page 4 line 2 and page 8 lines 17-22. Tang et al. does not disclose any pump pulse power greater than 5 mj. This would have suggested to one of ordinary skill in the art (1) that pulses greater than 5 mj would have damaged Tang et al.'s optics and (2) that 5 mj pump pulses were the largest pump pulse energy Tang et al. believed to be usable without risking damage to their optics.

From the foregoing, one skilled in the laser arts would have concluded that Tang et al.'s maximum idler pulse generated by a KTP crystal having θ about 63.4 degrees had an energy of less than 1 mj and a wavelength of 2.69 μm . Moreover one skilled in the laser arts would have known that the idler pulse energy would fall to zero as θ was increased to 65 or 66 degrees (by extrapolation from the data in figure 1a) and the idler beam wavelength would concurrently increase from 2.69 μm to about 2.8 μm (see data in figure 1a). Based upon the foregoing, one skilled in the art would not be led to believe that Tang et al.'s non critically

phase matched laser system would produce anywhere near 1 mj of energy in idler beam pulses at or above a wavelength of 2.75 μm . For the same reasons, one skilled in the art would not be led to believe that Tang et al.'s non critically phase matched laser system could function to produce an idler beam wavelength between about 2.90 and 3.0 μm .

This application discloses that "a desired laser source for this application would have an output energy up to 30 mj" for a surgical laser system operating around 2.94 μm . Page 3 lines 16-17. In addition, the Summary of the Invention section states that the "laser beam comprises ... pulses ... with an energy greater than 1 mj...", thereby suggesting that the inventors believed that a minimum useful idler beam pulse energy was "greater than 1 mj." These statements are evidence supporting the conclusion that there would be no motivation to use a system limited to generating less than 1 mj per pulse. At best, Tung et al.'s laser might be capable of lasing at 2.75 μm , but with far less energy per pulse than 1 mj. For these additional reasons, the person of ordinary skill in the art would not be motivated to try Tang et al.'s system to generate a wavelength above 2.75 μm .

There is no motivation to modify Lin in view of Tang et al. because Tang et al. does not disclose a system useful for surgery. In this regard, the examiner's assertion that there is no wavelength criticality is incorrect. This application and the prior art point out that there is an absorption maxima at a wavelength of 2.94 μm caused by the existence of the OH bond, and therefore there is an absorption maxima at 2.94 μm in tissue. In fact Dr. Telfair indicates that the absorption drops sharply outside of the claimed range. He indicates that the coefficient of absorption of tissue decreases by about an order of magnitude from its peak value at 2.94 as compared to its value at above the upper claimed limit of 3.0 μm . Similarly, he indicates that the coefficient of absorption decreases by a factor of 2 from the peak value at 2.94 μm to a value at 2.90 μm , and decreases further as the wavelength decreases. Neither Lin nor Tang et al. provide an enabling disclosure of an OPO laser system that could generate laser radiation at 2.94 or in the 2.90 to 3.0 μm range. Therefore, there is no motivation to use the non critically phase matched OPO laser taught by Tang et al. as the OPO laser suggested by Lin. In this regard, it should be pointed out that this application, in contrast to Tang et al., does enable a laser surgical system for generating radiation in the 2.9 to 3.0 μm range. This application discloses at page 14 lines 18-20 a type II CPM x-cut KTP crystal with $\theta = 68-70^\circ$, whereas Tang et al. disclose a crystal at $\theta = 63.4$ degrees.

For all of the foregoing reasons, the rejections of claims 61-63, 69-80 and 85-89 are improper and should be withdrawn.

B. Lin and Bosenberg et al. - claim 82

The office action rejects claim 82 under 35 USC 103(a) as obvious in view of the combined teachings of Lin and Bosenberg et al. In support of the rejections, the examiner states that:

Lin teaches a method as claimed except for the particular non-linear material. Bosenberg et al[.] teach generating wavelength in the range desired by Lin using the non-linear material claimed. It would have been obvious to the artisan of ordinary skill to employ an OPO using the non-linear material of Bosenberg in the method of Lin since this can produce the desired wavelength[, the wavelength is] not critical[, and] provides no unexpected result, and does not manipulatively effect the method, thus producing method as claimed. [Office action page 4 lines 2-8].

In response, the applicant respectfully traverses this rejection because teachings of the cited references alone or in combination do not suggest the claimed inventions.

As discussed above, Lin does not enable an OPO laser system for wavelengths in the 2.9 to 3.0 μm range. Lin cites at column 9 lines 41-42 to "Optical Communications, vol. 75, p. 315 (1990) for details on OPO. That paper "report[s] the first demonstration of a tunable mid-IR (1.8 - 2.4 μm) coherent source" (abstract). However, 1.8 - 2.4 μm is outside of the wavelength ranges claimed herein.

Bosenberg et al. does not provide motivation to use an idler beam having a wavelength which is "between about 2.9 and about 3.0 microns" as per claim 82. Bosenberg et al. generically discloses a possibility of achieving a tuning range anywhere between 1.35 and 4.9 μm . Bosenberg et al. does not disclose a system useful for surgery. Bosenberg et al. does not disclose or recognize criticality of the specifically claimed range for surgical application as discussed above. Therefore, Bosenberg et al. does not suggest modifying the system disclosed in Lin.

For the foregoing reasons, the rejection of claim 82 is improper and should be withdrawn.

C. Lin and Rines et al. - claims 83 and 84

The office action rejects claims 83 and 84 under 35 USC 103(a) as obvious in view of

the combined teachings of Lin and Rines et al. In support of the rejections, the examiner states that:

Lin teaches a method as claimed except for the pump wavelength. Rines teaches using a Titanium Sapphire laser to pump KTP to produce infrared radiation in NCPM OPO. It would have been obvious to use the of [sic.] OPO of Rines in the method of Lin, since it is not critical, provides no unexpected results, and does not manipulatively affects the method, thus producing the method such as claimed. [Office action page 4 lines 10-15.]

In response, the applicant respectfully traverses these rejections because teachings of the cited references either alone or in combination do not suggest the claimed inventions.

Contrary to the examiner's assertion, Lin does not "teach a method as claimed except for the pump wavelength". As discussed above, Lin does not enable an OPO laser system for wavelength of between about 2.9 and about 3.0 microns. Furthermore, Lin is silent regarding phase matching.

Rines et al. generically discloses generating a pump beam pulse at a wavelength of between about 0.700 and 0.900 microns and converting a fraction of energy in the pump beam pulse into an idler beam pulse having a wavelength of anywhere between about 2.0 and above about 3.0 microns. See figure 9 on page 56 of Rines et al. Rines et al. does not disclose a system useful for surgery. Rines et al. does not disclose the criticality of the claimed wavelength for surgical applications. Therefore, there is no motivation to combine the teachings of Rines et al. with the teachings of Lin.

For the foregoing reasons, the rejections of claims 83 and 84 are improper and should be withdrawn.

D. Lin and Bosenberg et al. and Mead et al. - claim 81

The office action rejects claim 81 under 35 USC 103(a) as obvious in view of the combined teachings of Lin and Bosenberg et al. as applied to claim 82, and further in view of Mead et al. In support of the rejections, the examiner states that:

Mead et al[.] teach equivalence of periodically poled LiNbO₃ for non-linear wavelength conversion. Thus it would have been obvious to the artisan of ordinary skill to employ periodically poled KTP in the method of Lin and Bosenberg et al[.], since this produces no manipulative effect and it is a recognized equivalent to periodically poled LiNbO₃, as taught by Mead et al[.], thus producing a method such as claimed. [Office action page 4 lines 18-22.]

In response, the applicant respectfully traverses this rejection for the same reasons discussed in the rejection of claim 82 over the teachings of Lin in combination with Bosenberg et al.

IV. Conclusion

The present application is in condition for allowance. However, if the examiner notes any other problems, in order to expedite allowance, he is urged to contact the undersigned at 703-415-0012.

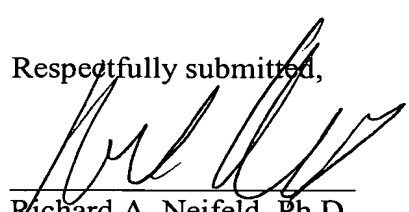


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PATENT TRADEMARK OFFICE

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Attachment list:

Attachment 1: A copy of the definition of “radian” from the Second Edition of “The Dictionary of Scientific and Technical Terms”

Attachment 2: A copy of “Optical Communications”, vol. 75, p. 315 (1990)

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APPENDIX

MARKED UP COPIES OF CLAIMS SHOWING CHANGES MADE

Claims 61-84 are amended.

61. (Once Amended) A surgical method, comprising:
generating a pump beam pulse;
transmitting said pump beam pulse into a KTP crystal along a propagation direction that is substantially not parallel to a principle axis of said KTP crystal;
wherein said KTP crystal converts a fraction of energy in said pump beam pulse into an idler beam pulse, and said idler beam pulse has a wavelength of between about 2.75 and about 3.0 microns; and
impinging said idler beam pulse on tissue, thereby removing said tissue.
62. The method of claim 61 wherein said generating comprises generating said pump beam pulse having a wavelength of about one micron.
63. The method of claim 61 wherein said generating comprises generating said pump beam pulse such that said pulse has a duration of less than about 30 nanoseconds.
64. The method of claim 61 wherein said generating comprises generating said pump beam as a multi mode beam.
65. (Once Amended) The method of claim 61 wherein said generating comprises generating said pump beam pulse as a multi mode beam having a divergence greater than eight times a diffraction limit of said multi mode beam.
66. The method of claim 61 wherein said pump beam pulse has a diameter on the order of one to five millimeters.
67. The method of claim 61 wherein said impinging comprises impinging said idler beam pulse on corneal tissue.
68. The method of claim 61 further comprising sculpting a cornea with a plurality of idler beam pulses.
69. The method of claim 61 further comprising cutting said KTP crystal for type II phase matching, and internal angles of sixty eight to seventy degrees.

70. The method of claim 61 wherein said generating comprises generating said pump beam pulse in one of a Nd: YAG, Nd:glass, Nd:YLF, and Nd:YAlO₃ laser.

71. The method of claim 61 further comprising cutting said KTP crystal to have a length of at least 20 millimeters.

72. The method of claim 61 wherein said KTP crystal has a principle axis, and further comprising rotating said KTP crystal relative to said principle axis.

73. The method of claim 61 wherein said step of transmitting comprises transmitting said idler beam pulse with an energy of between five and thirty milli joules.

74. The method of claim 61 wherein said KTP crystal has a principle axis, and further comprising rotating said KTP crystal relative to said principle axis to an absorption wavelength of said tissue.

75. The method of claim 61 wherein said KTP crystal converts at least one tenth of energy in said pump beam pulse into said idler beam pulse.

76. The method of claim 61 further comprising generating pump beam pulses at a rate of ten to fifty hertz.

77. The method of claim 61 further comprising transmitting remainder of said pump beam pulse exiting said KTP crystal through a second KTP crystal.

78. The method of claim 61 further comprising transmitting said pump beam to said KTP crystal via one of a waveguide and a fiber optic bundle.

79. The method of claim 78 further comprising interlacing an idler beam pulse output generated in a second KTP crystal with said idler beam pulse.

80. (Once Amended) A surgical method, comprising:
generating a pump beam pulse;

transmitting said pump beam pulse through a mirror that is highly reflective to a wavelength of an idler beam pulse and highly transmissive to a wavelength of said pump beam pulses, said mirror oriented at an angle of forty five degrees relative to said pump beam pulse;

transmitting said pump beam pulse into a crystal;

wherein said crystal converts a fraction of energy in said pump beam pulse into said idler beam pulse, and said idler beam pulse wavelength is about [2.75] 2.90 and about 3.0 microns; and

impinging said idler beam pulse on tissue, thereby removing said tissue.

81. (Once Amended) A surgical method, comprising:

generating a pump beam pulse;

transmitting said pump beam pulse into a periodically poled KTP crystal;

wherein said KTP crystal converts a fraction of energy in said pump beam pulse into an idler beam pulse, and said idler beam pulse has a wavelength of between about 2.75 and about 3.0 microns; and

impinging said idler beam pulse on tissue, thereby removing said tissue.

82. (Once Amended) A surgical method, comprising:

generating a pump beam pulse;

transmitting said pump beam pulse into a periodically poled LiNbO3 crystal;

wherein said periodically poled LiNbO3 crystal converts a fraction of energy in said pump beam pulse into an idler beam pulse, and said idler beam pulse has a wavelength of between about 2.9 and about 3.0 microns; and

impinging said idler beam pulse on tissue, thereby removing said tissue.

83. (Once Amended) A surgical method, comprising:

generating a pump beam pulse at a wavelength of between about 0.85 and 0.90 microns;

transmitting said pump beam pulse into a non critically phase matched KTP crystal, X-cut;

wherein said non critically phase matched KTP crystal [crystal] converts a fraction of energy in said pump beam pulse into an idler beam pulse, and said idler beam pulse has a wavelength of between about 2.9 and about 3.0 microns; and

impinging said idler beam pulse on tissue, thereby removing said tissue.

84. The method of claim 83 wherein said generating comprises generating said pump beam pulse in one of a Ti: Sapphire and a Cr: LiSAF laser.

Claims 85-91 are added as new claims.

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